CONFIDENTIAL

997456

NPIC/P&DS/D/6-766
2 February 1966

MEMORANDUM FOR: Assistant, Plans and Development Staff

THROUGH: Chief, Development Branch, P&DS

SUBJECT: Electrocolor Feasibility Study

1. At the request of P&DS/DB, the [redacted] submitted a proposal on 23 November to perform a complete evaluation of the Electrocolor Process. The total funding requested for the study was [redacted] however, an alternate first phase was also proposed at the [redacted] level of effort. At that time [redacted] was preparing to send back to [redacted] the Electrocolor machine they were renting. Anticipating a contract with the Agency to evaluate the Electrocolor System, [redacted] has not returned their machine to [redacted] but continued to rent it at an approximate cost of [redacted]

2. Since the submittal of their proposal, [redacted] has made several inquiries as to the status of a decision on their proposal. As it is unfair to expect [redacted] to continue paying rental on the machine in anticipation of a contract, it is of utmost urgency that P&DS takes some action with the proposed Electrocolor feasibility study. The R&D Catalog Form on this study was prepared on 28 December 1965, and immediate TDB action can be scheduled if it is decided to except either the full study or the first phase. This project has been coordinated with [redacted] and received his concurrence.

[redacted]
P&DS/DB/SSS

Distribution:
Original and 1 - Addressee
2 - P&DS/DB - 1 - Project File/DB (#997456)
1 - Chrono/DB

NPIC/P&DS/DB: [redacted] (28 Jan 66)

Declass Review by NIMA/DOD

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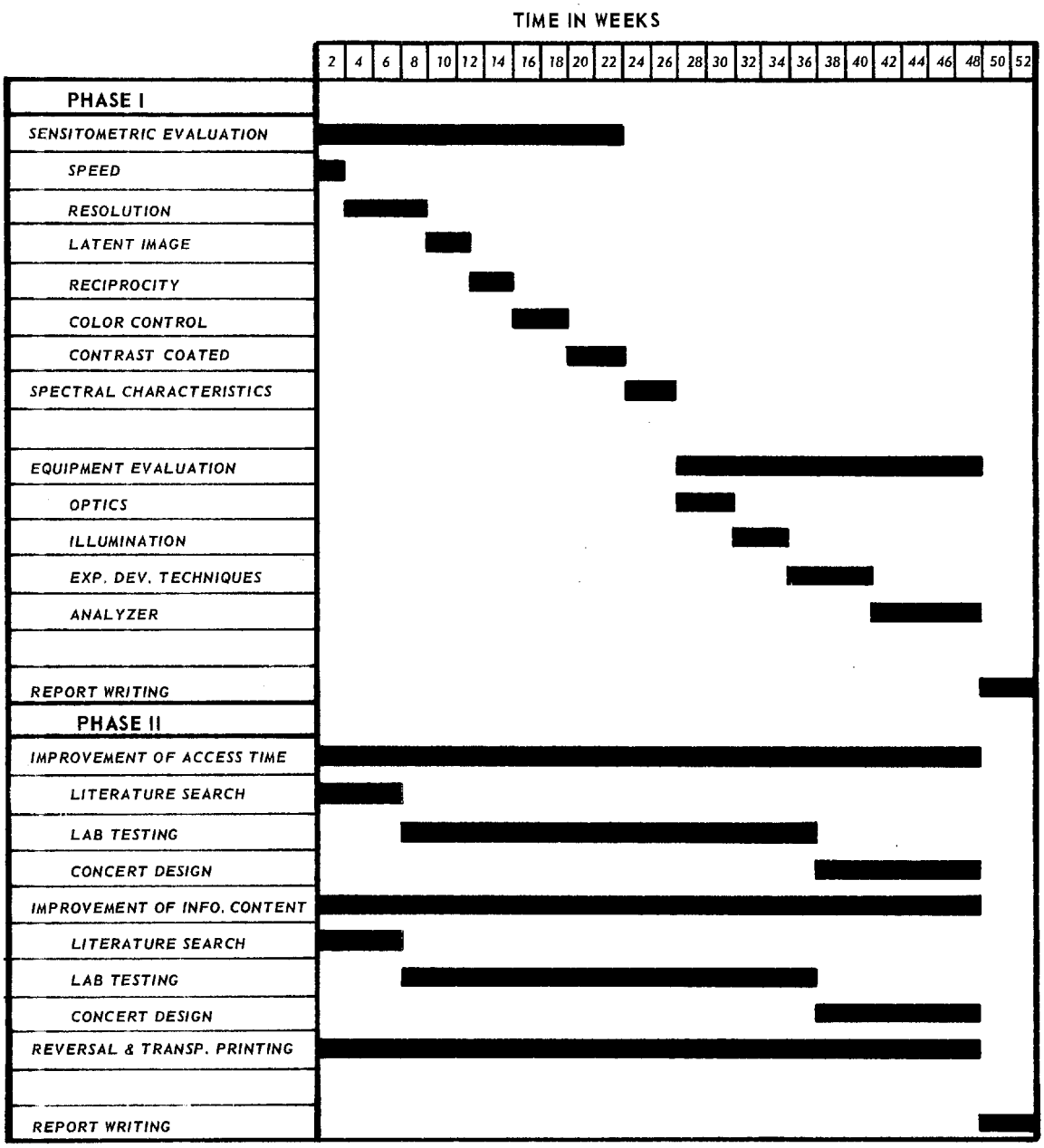
UNSOLICITED

TECHNICAL PROPOSAL

ELECTROCOLOR EVALUATION AND IMPROVEMENT

Approved For Release 2003/01/28 : CIA-RDP78B04770A002600110013-9

PROGRAM SCHEDULE – OPERATIONS



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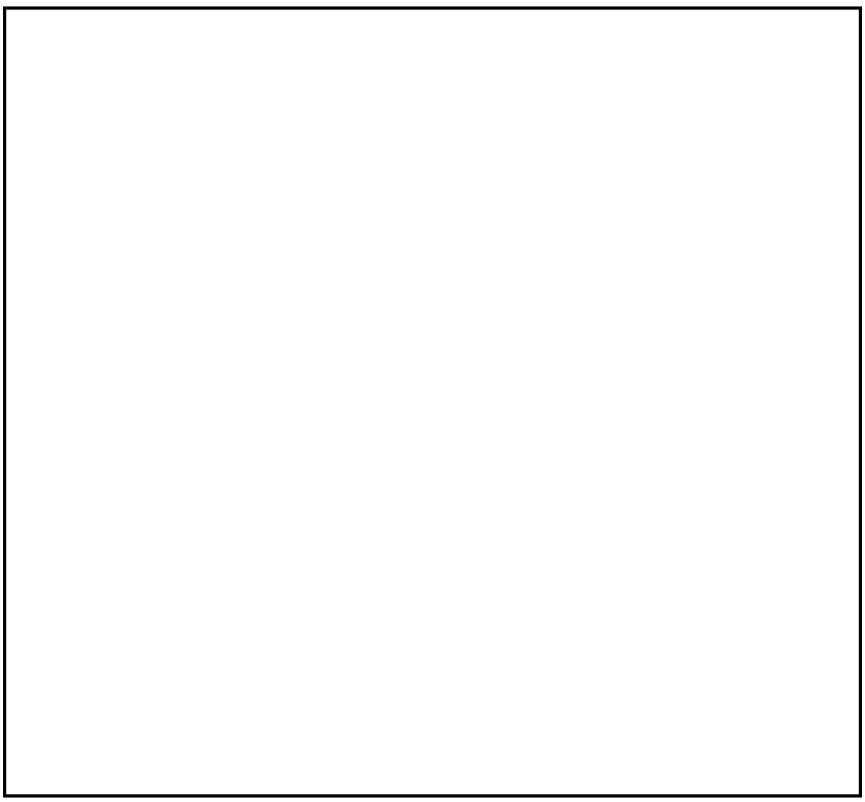


February 11, 1966

The purpose of this letter is to reflect the changes in the Technical Proposal No. 65-123A, as discussed by phone recently.

1. The evaluation of the present system will be a four month effort to provide current data regarding the limitations and capabilities of the Electrocolor System.

2. Concurrent with the evaluation will be an investigation into the potentials of electrophotographic systems. The major portion of this effort is programmed to be well along by the end of the fourth month so that a review at that point will indicate the direction and scope of the remainder of the investigation.

3. An additional effort is proposed to explore the potential of the electrophotographic system in the areas of exaggerated color, false color, spectral translation, spectral cueing, and other related applications. This effort will be under the direction of a human factors engineer.

4. The program schedule is designed to provide a broad investigation for the first four months, leaving some flexibility in the remainder of the phase. It is our feeling that at the four month review, sufficient data will be available to permit an efficient direction of effort for the remainder of Phase I.

5. The product of Phase I will be a document detailing: (1) the present capabilities of the system (2) the potential capabilities of the system, and (3) an

25X1 [redacted]

outline of the development program proposed for Phase II.

6. A program schedule and revised cost estimate is enclosed.

Feel free to contact me if we may be of further service to you.

Sincerely,

[redacted] 25X1

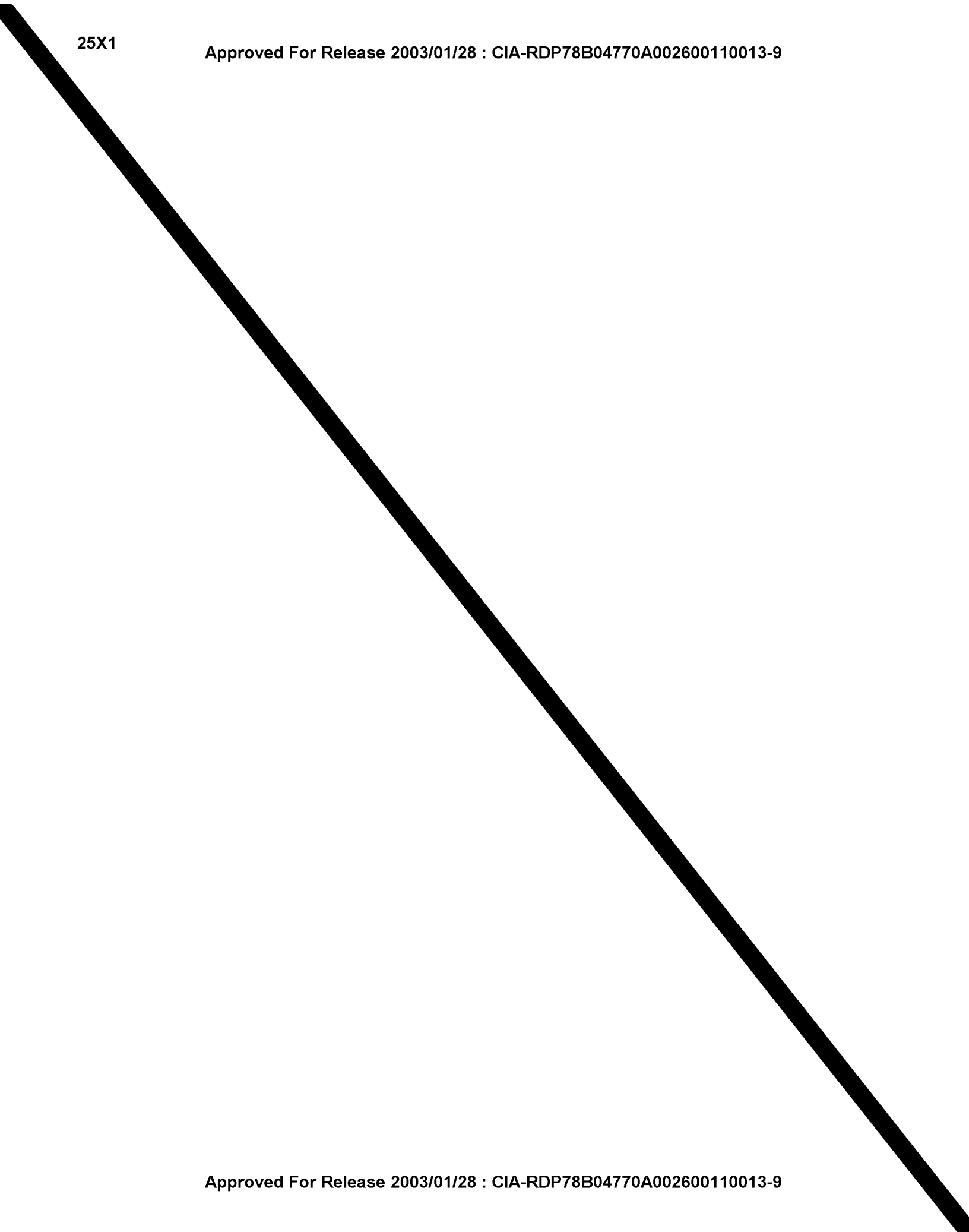
Laboratory Services Group

RC:bls

Encls:
Program Schedule
Cost Estimate

25X1

[redacted]



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TECHNICAL BACKGROUND PROCUREMENT INFORMATION 25X1

I

B. Evaluation of previous performance: RELIABLE AND COMPETENT SATISFACTORY PERFORMANCE ON PREVIOUS CONTRACTS

II. Brief description of this procurement: EVALUATION STUDY ON IMPROVING THE PRESENT ELECTROCOLOR SYSTEM TO MEET EXPLOITATION REQUIREMENTS 25X1 Estimated total amt.

A. Deliverable items: FINAL REPORT

REFER TO SPECIFICATION DB-1001 - 5 APRIL 1966

Briefing Aids - Refer to Specification DB-1002 - 5 April 1966

B. Is this procurement for other than a standard, "off the shelf" or slightly modified commercial item? N/A If "yes", is it anticipated that any more of this unit will be procured? N/A If so, a complete set of directly reproducible manufacturing drawings and specifications would normally be included in this procurement. Comments:

C. Will contract cover a period of more than 90 days? Yes
If "yes", are progress reports desired? YES If so, indicate frequency, content and number of copies desired:

Refer to Specification DB-1001 - 5 April 1966

D. Is any Government-owned property to be provided to the contractor?

NO If so, list and indicate its availability (where, when, etc.)

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E. Is any special tooling involved? NO

F. Security:

1. Association with the Sponsor is [redacted] 25X1

2. The specifications and/or drawings are N/A

3. The item is N/A

4. Contractor personnel known to be aware of this proposed procurement:

25X1 [redacted]

5. Other security information NONE

III. Reasons for selection of this source. If other sources were considered, indicate results. If no other sources were considered, list the reasons why this firm is considered to be uniquely qualified to perform this work.

25X1 [redacted] PREVIOUSLY STUDIED THIS SYSTEM FOR THE AIR FORCE. [redacted] ALSO BUILT A PROTOTYPE COLOR 25X1 ANALYZER FOR THE [redacted] TO BE USED IN 25X1 CONJUNCTION WITH THE ELECTROCOLOR SYSTEM.

IV. If contract will cover deliverable item(s) state room location where equipment will be installed N/A. (It is extremely important that the Engineering Data Sheet including room location and any other pertinent facts be submitted to NPIC Engineering Section as far as possible in advance of delivery.)

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V. Technical contac [redacted]

In the event additional space is required, use the reverse side(s) of this form, with a reference to the item number to which the comment applies.

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PLANS AND DEVELOPMENT STAFF

Project No. 997456 Title Electrocolor Feasibility Study

Development Objectives Concurrence

		Date
1.	Chief, DB	
2.	Chief, EDLB	
3.	Chief, PB	
4.	Asst. for P&D	
5.	Chief, Responsive Div. or Staff	
	Chief, Responsive Div. or Staff	
	Chief, Responsive Div. or Staff	

25X1

		Date
1.	Chief, DB [redacted]	25 Apr 66
2.	Chief, EDL[redacted]	7 April 1966
3.	Chief, PB [redacted]	11 April 66
4.	Asst. for P[redacted]	[illegible]
5.	Chief, Re[redacted]	11 April 1966
	Chief, Responsive Div. or Staff	
	Chief, Responsive Div. or Staff	
6.	DDS&T Representative	

TDB Action

NOTE: Any non-concurrence to this project requires a written attachment stating any objections in detail.

PROPOSAL FOR A FEASIBILITY STUDY

ON THE

25X1 [redacted] ELECTROCOLOR PROCESS

TO

25X1 [redacted]

....

25X1

[redacted]

April 1, 1966

April 1,1966

Introduction

25X1 [redacted] proposes herein a four-month program in response to your Request for Proposal dated March 26, 1966. The objective of this program will be to determine feasibility of the Electrocolor system for the goals outlined and to develop concepts which could extend the potential utility of this system.

Technical Program

(1) Increased Resolution of 100+ lines/mm.

Level of Effort: Four (4) man-months

25X1 Based on an evaluation at [redacted] the present commercial Electrocolor paper has a resolution of 15 lines/mm. Higher resolution zinc oxide materials have already been prepared in the laboratory but only at the expense of certain other properties. Additional development work will be necessary to evolve an optimum system. We propose to conduct more intensive studies in fine grained zinc oxide, improved coating technology and thin film materials toward this end.

(2) Five to Ten-fold Increase in Speed.

Level of Effort: Six (6) man-months

A number of techniques which are available for increasing the speed of Electrocolor systems will be explored. In contrast to conventional silver halide photography, there is evidence that the electrolytic zinc oxide system can be increased in speed without a corresponding sacrifice in resolution. The objective of an increase in speed of 5-10 times should be feasible with a minimum loss in other properties. There is no indication that even this is the ultimate limit of amplification that can be expected from the electrolytic zinc oxide system.

(3) Dye Modification

Level of Effort: One (1) man-month

A large number of dyes are available which could be utilized if required. It is not expected that dye synthesis could be initiated during the feasibility study. An analysis will be made of the potential long-range importance of dye modifications.

25X1

(4) Reversal Printing Capability

Level of Effort: Ten (10) man-months

Exploratory work has suggested several possible approaches to achieving a positive working color printing system. The adaptation of these leads to practical systems presents many formidable problems and will require a significant effort.

(5) Color Transparency Printing Capability

Level of Effort: Ten (10) man-months

Several approaches have been investigated for adapting the Electrocolor system to produce color transparencies. These include thin film materials, electrically conducting polymeric interlayers and image transfer systems. It is recognized, of course, that the resolution requirements may be incompatible with some of these approaches. It will be the purpose of this program to assess these interactions and investigate other avenues to achieve this end.

(6) Introduction of a Closed Loop Water System

Level of Effort: Two (2) man-months

Considerable progress has been made toward developing a closed loop system for the commercial processor. Studies will be made to determine whether the existing approach is adequate for the type of system to be developed in the above items.

Program Planning

25X1 proposes to conduct the above program over a period of four calendar months at a total level of effort of 33 man-months and submit an actual report summarizing the achievements in advancing the state of the art with respect to each of the above goals. This report will include a conclusion as to feasibility whenever possible and an appraisal of the ultimate limits of the concepts available. This report will be the only report required to be delivered under any contract which may result from this proposal.

Total Cost

The contract will be conducted on a cost-plus-fixed fee basis with a total
25X1 value of

Program Terms and Conditions

During its evolution of the Electrocolor process, the has established 25X1
a basic patent position and developed considerable proprietary information in
the field of electrolytic imaging. This is vital, not only to early com- 25X1
mercialization of Electrocolor, but to a number of its other broad interests
in the duplicating and imaging field.

This proprietary technology has been developed at the sole expense of the 25X1
25X1 and not under or in contemplation of any Government contract. More-

over, work is continuing in this field at a substantial expense to [redacted] 25X1
25X1 [redacted] In view of these factors, it shall be agreed that no patent rights clause will be included in the terms and conditions of any contract resulting from this proposal.

It is further intended that no license or right to make or use [redacted] 25X1 proprietary technology or information is, or will be, granted regardless of the manner of inclusion in reports, proposals, etc.

Personnel

Biographies of the scientists and engineers conducting the program can be furnished upon request.

Product Improvement Demonstrations

Demonstrations of the improved state of the art will be performed upon request at the conclusion of the contract at the [redacted] facilities. 25X1

4/4/66

Copy 2

Since the delivery of the initial proposal in November, 1965, certain modifications and clarifications have been requested. This document is intended as a supplement to the original proposal to reflect the current conditions of the proposed investigation. Principle areas of change are:

1. Reduction of effort on certain aspects of the Phase I Evaluation
2. Clarification of Procedures for Spectral Evaluation
3. Elaboration of Phase II efforts
4. Amplification of Human Factors Analysis
5. Breakdown of Subcontract work
6. Clarification of Cost Sheet

1. Reduction of effort on certain aspects of the Phase I Evaluation:

It was intended in the original proposal that the evaluation of the present Electrocolor system was to determine its present capabilities and limitations. Many of these conditions have been established in previous contracts and in-house investigations. Subsequent modifications of materials, equipment and procedures require a re-evaluation to provide a basis for the Phase II development. It is our feeling that the tests outlines under Sensitometric Characteristics of the Material starting on page 5 are necessary and remain unchanged. It is now felt that a more extensive effort is required in the evaluation of the spectral characteristics of the materials and dyes as outlined on page 7. A complete discussion of this area will follow under item 2.

Under Performance Testing of Equipment, it appears that for this application testing of the illumination and optics would be of little value. The Phase II development will dictate the requirements in these areas and will be considered there. A study of

the exposure and development (plating) techniques as well as the negative analyzer and control system as described on pages 8 and 9 are considered valuable to the Phase II development.

2. Clarification of Procedure for Spectral Evaluation

To this point, no significant study has been made of the color gamut of the Electrocolor dye system. It is our opinion that more than a subjective analysis is necessary and that this analysis should include Kodak Ektacolor material for comparisons. It is the purpose of this study to generate objective data regarding the color gamut of the Ektacolor material and the Electrocolor system with various top coating materials.

This color gamut will tell us what the visual appearance will be of the combinations of the image forming dyes. Further, it maps the range of colors it is possible to reproduce with a dye system. As would be imagined this type of color map for a dye system is very sensitive to changes in the dyes, the sensitive material, the laminating or glossing process and anything that alters the color tone reproduction and color fidelity of the system. Since it is sensitive in this manner, it becomes very useful in presenting a unified picture of how any changes made later in the color system affect the ability of the system to reproduce colors. What's more, the results are presented in terms of the human visual system.

In describing the usefulness of the color gamut for a color dye system, familiarity with the CIE chromaticity diagram will be assumed. A density measure will be defined, this term being the equivalent neutral density (END) of a dye.

For a given subtractive color system, three dyes are chosen these being cyan, magenta, and yellow. Let us say we are given a patch of cyan dye on a transparent base. By superimposing certain amounts of magenta and yellow dye over the cyan patch a

neutral may be formed. The visual density of the neutral, as compared to a calibrated silver or carbon wedge, is termed the equivalent neutral density of each dye. For example, say we have a magenta END of 3.0, we mean that if we superimpose proper amounts of yellow and cyan dyes over the magenta, the density of the neutral that will be formed will be 3.0. We may note that the END's of the yellow and cyan dyes will also be 3.0. Thus, if a cyan patch of END 1.6, a magenta patch of END 1.6 and a yellow patch of END 1.6 are superimposed (assuming the dyes are on a transparent base), a visual neutral density of 1.6 will be formed. If the END of the magenta was only .20, then a green patch would be formed.

1.6 C + 1.6 M + 1.6 Y = visual neutral density = 1.6

however

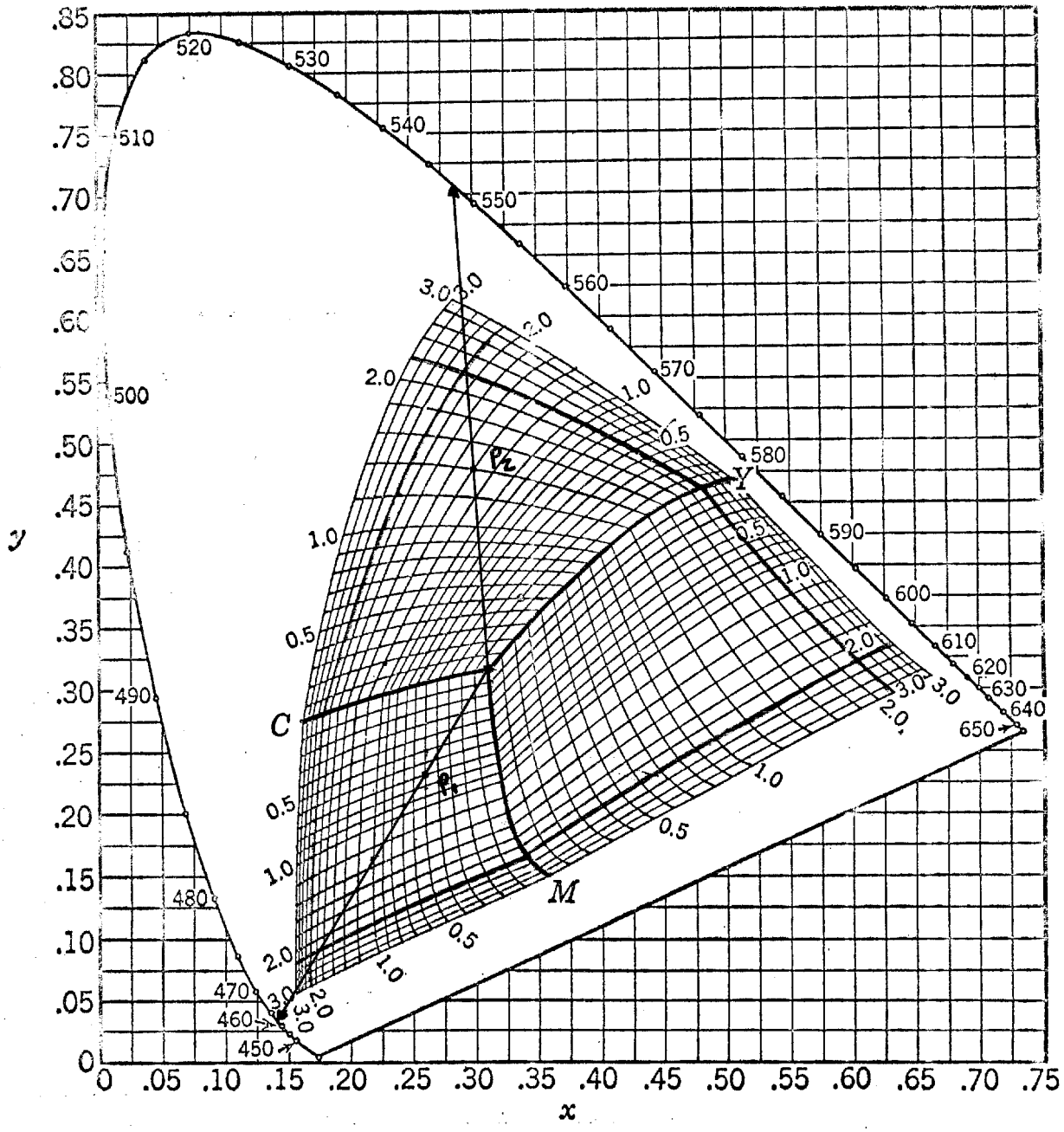
1.6 C + .2 M + 1.6 Y = green

Taking out the neutral density from the latter equation we have a green hue formed through the addition of 1.4 C + 1.4Y (Note, removing the neutral density will not shift the dominant wavelength or purity, it will change only the luminosity). We would like to ask the question: What are the visual attributes of this color? To find this out directly, we turn to a plot of the color gamut for the dye system. (See example plot).

To generate the color gamut for a dye system we must determine both the CIE coordinates and the corresponding END's of the dyes forming each patch. Thus, since the CIE plot does not take into account the luminosity of the color, the neutral components of each color will be removed. The dark black lines on the example gamut are the CIE plots of the individual dyes. The remaining lines are filled in from the CIE points calculated from dye pairs.

P_1 dominant wavelength 463 mu
purity 10.5%
produced by .50C + .70M (END)

P_2 dominant wavelength 548 mu
purity 17.8%
produced by 1.4C + 1.4Y (END)



Looking at the accompanying diagram, a bluish (cyanish) line has been drawn crossing the cyan dye base line (black line marked C). This bluish line was generated by taking a cyan dye patch of END 2.2 and combining it with all END's of the remaining two dyes taken one at a time. All END's of yellow dye, when combined with the cyan dye, with an END of 2.2, would generate the section of the blue line above the black line marked C. All END's of the magenta dye, when combined with the cyan dye with a END of 2.2 would generate the section of the blue line below the black line marked C. Similarily, by taking the magenta dye with an END of 2.2 in combination with all END's of cyan and yellow dye, taken one at a time, would generate the red line. Taking the yellow dye with an END 2.2, in combination with all END's of magenta and cyan, would generate the green line.

Returning to the original problem, a patch generated with 1.6C + 0.2M + 1.6Y which, after the neutral has been removed, becomes 1.4C + 1.4Y, a green patch. We can plot 1.4C + 1.4Y on the color gamut (point P_2). Reading from the CIE loci we find this green will have a dominant wavelength of 548 mu. and a purity of 17.8%.

It takes a considerable amount of data to generate a color gamut for a dye system. We have, however, mapped out the procedure to do this with a reasonable amount of efficiency. The procedure is too long to detail it here, however, we estimate a minimum of 8 weeks, most probably 14 weeks or a maximum of 20 weeks will go into the generation of 4 gamuts for:

1. The Eastman Ektacolor print material (glossy print, use as a comparison gamut to the Electrocolor)
2. [redacted] Electrocolor system, unlaminated print
3. [redacted] Electrocolor system, glossy lamination
4. [redacted] Electrocolor system, matte lamination

25X1

Once the procedure for generating the color gamut has been tested and practiced, it is estimated that any new gamut plot that is desired will take approximately 2 weeks minimum to generate (extra plots may be desired if a faster paper is developed or a new dye system or a transparency material evolves from research).

With regard to the time estimates, approximately 70% of the above values would be engineering time, the remaining 30% would be technician time. Some computer time may be necessary although we are not certain, at this point, how much would be needed. One major item of procurement would be necessary; that being an IDL Color Eye

25X1 [redacted]

Although considerable effort is proposed in the generation of the color gamut for the color system, we feel the information gained (or at least made more explicit) over an assemblage of spectrophotometric curves, is worth the energy expenditure.

3. Elaboration of Phase II Efforts

The purpose of Phase II remains that of exploring all facets of electrolytic image forming techniques to determine the potential of an ideal system. Inherent in this purpose is the task of accumulating ideas, developing and demonstrating feasibility of concepts which could substantially increase the capability of the electrophotographic system.

A. Literature Search

One of the first tasks of this phase is an extensive literature search. The APSE (Abstracts of Photographic Science & Engineering Literature) for 1965, for example, lists over 300 references to patents and papers on Electrophotography. For the purpose of this search, the accumulation of information will be aimed at electrolytic dye

deposition systems. Descriptors will be such terms as: Electrography, Photoconductive layers, Electrolytic development, Dyes, etc. as opposed to Xerography, Electrostatic charging, Toners, etc. The report of this search will serve as a reference source to engineers and technicians involved in the study. In addition, it will provide a listing of individuals and corporations working in this area. A letter will be sent to these personnel in an attempt to obtain information on the most recent developments.

B. Access Time Improvement

In its present design, the Electrocolor system is not suitable for large quantity production. The major limiting factor is the sequential requirement for printing and development (plating). The major effort of [redacted] personnel in Phase II will be in this investigation. 25X1

The plan now is to investigate at least four types of exposure/plating techniques which have potential access time reduction. The four that are now apparent are:

(1) Sequential (mechanical modification of present system)

(2) Concurrent Stage System

(3) Traversing Mechanism

(4) One-short

(1) In the present machine using the sequential exposure and plating technique, a print can be made in approximately 4 minutes. The actual time required to expose, plate, wash, and dry a print is approximately 60 seconds. An additional 3 minutes is consumed in nonproductive mechanical operations. An investigation will be made to determine what mechanical modification would reduce the access time.

(2) Concurrent Stage System

Although the problems appear to outweigh the potential of this system, it is felt

that a study should be made of a design in which the print paper is moved from the exposing plane to the development stage. By the use of dichroic mirrors, the three spectrally separated images could be directed to three printing stages. The red, green, and blue exposures would be made simultaneously on three separate sheets of material. After plating, the three prints would be advanced and registered in the next stage. After the third advance, full color prints would be produced in approximately one-third the present time or every 80 seconds. Problem areas are registration, complex mechanical movements, and elaborate electronic control requirements.

(3) Traversing Mechanism

This system is described in detail in the initial proposal (page 9)

(4) One Shot

This concept is probably the most sophisticated and the most difficult to accomplish. It is based on the use of an emulsion coating in which ZNO grains are spectrally selective. One-third of the grains are spectrally sensitized to red light, one-third to green light, and one-third to blue light. The dye bath is likewise composed of selective dye particles which, upon the application of the plating current, will be plated to the proper ZNO grain. The advantage of this system would be:

a. A single white light exposure (permits dodging and burning)

b. A single plating requirement

c. Separate exposure and plating operations. (exposure of next print could be simultaneous with the processing of succeeding print.

d. No registration problems

e. No dark adaption (resensitization) problems

f. Considerable reduction of access time

g. Less elaborate printing and processing equipment.

A factor influencing the access time of any of the above systems is the speed of the print material. Investigation of a 5-10 time material speed increase is included in the 3M subcontract effort.

C. Information Content Improvement

Two factors will be treated under this category as outlined on page 10 of the proposal; resolution and spectral considerations.

1. Resolution

a. Print material

25X1 [redacted] subcontract effort described in this proposal is outlined to investigate 100 l/mm and potential.

b. Use of B & W original material

A study of the potential gain through the use of light resolution black and white negative material will be conducted as described on page 10 of the original proposal.

2. Spectral

The purpose of this investigation is to explore all the possible application of the Electrocolor system as a display tool. Areas of investigation known now will be:

(a) Accurate color

(b) False color

(c) Color Translation

(d) Change discrimination

Other application may become evident during the study and will be explored.

As a part of the Information Content Improvement study, a human factors investigation will be performed to give an indication of optimum dye combination to maximize visual acuity in false color detection. This human-oriented research will be designed to function in accordance with the color gamuts generated for the electrocolor dye system in the Phase I program. It will involve the detection, by human observers, of specified targets of known size, hue and purity against backgrounds of equal brightness but differing hue and/or purity. Since we will be working with dyes that are relatively disperse in their spectral energy absorption curves, individual luminosity or brightness matching curves will not be generated for each observer. Instead, equivalent neutral density mapping functions will be generated for each observer since dyes may be considered to be of equal brightness when their END are equal. The basic data collection procedure will be the establishment of a series of detection tasks for a number of observers. For a given background (specified by the dominant wavelength and purity from the color gamut) a set of probability of detection curves (ogival curves) will be plotted. Each curve will be generated parametrically for a given target hue and purity. The independent variable of the plot will be the angular subtense of the target at the eye, the dependent variable will be the probability of detection of that target. From each graph one point will be determined, that being the angular subtense that yields a .50 probability of detection. The reciprocal of this threshold angular subtense is then the visual acuity associated with the target dominant wavelength λ_{dom_t} and purity p_t and with a given background of dominant wavelength λ_{dom_b} and purity p_b, thus evaluating the function:

$$\psi^{-1}_{P(x)=.50} = f(\lambda_{dom_b}, p_b; \lambda_{dom_t}, p_t)$$

Compiling these points to create a three dimensional plot for each background

25X1 condition will allow us to evaluate the [redacted] Electrocolor dye system in terms of human visual acuity. From these plots the optimum dye combinations(s) may be selected for maximizing visual acuity in false color detection conditions. It may be that an optimum condition does not lie in the range of the gamut for the present Electrocolor dyes. In this case the output from the program will dictate, in terms of the dominant wavelength and purity, the direction in which a new dye system should take within the CIE chromaticity diagram.

The program, as it is presently envisaged, will not require a great deal of initial calibration since we are not attempting to generate absolute visual data. The program does depend upon the generation of the color gamut for the Electrocolor system and its output should augment the color gamut program by stating, in terms of human factors, how the Electrocolor dye system may best be improved.

D. Development of Reversal and Transparency Printing Potential

The investigation of these areas is solely [redacted] effort as described in their attached proposal. 25X1

25X1

March 24, 1966

25X1

Manager, Photo-technology

Reference: Request For Proposal dated 26 March 1966.

Gentlemen:

25X1 is pleased to submit for your consideration the enclosed proposal for a feasibility study on the 25X1 lectrocolor process.

We are forwarding three copies of our proposal which consists of this letter of transmittal and a brief work statement. It is submitted as an offer to negotiate a contract for the performance of the work outlined in the Technical Proposal, and may be considered valid for a period of ninety days from the date of this letter. 25X1

25X1 It should be noted that the has maintained a significant proprietary and patent position in the field of technology involving the Electrocolor process and related materials, and devices. Accordingly, we anticipate that a resulting contract would include those changes in the standard terms and conditions which are specified in our proposal to 25X1 protect the background patents and proprietary information in this field.

If further information concerning this proposal is desired, the following persons may be contacted directly:

25X1

25X1 [redacted]

April 1, 1966

We appreciate the opportunity of formally submitting this proposal for your consideration. You may be certain that this research will receive the full support of [redacted] management, as well as the work effort of a well-qualified [redacted] technical team.

25X1
25X1

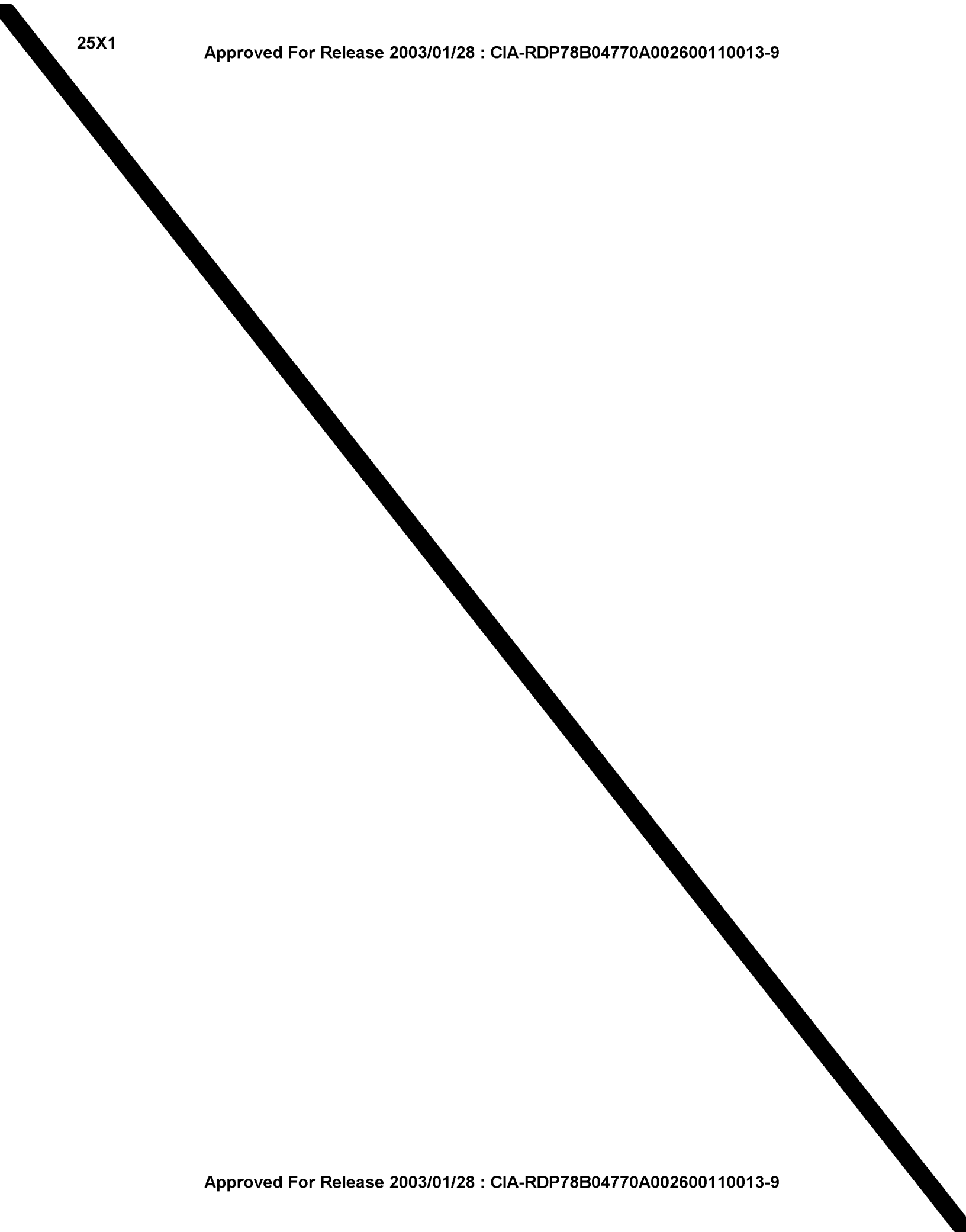
Very truly yours,

[redacted]

25X1

Research and Development

Enclosures



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